Measuring the Single Integrated Air Picture (SIAP)

CDR Joseph N. Giaquinto, USN
SIAP System Engineering Task Force, Arlington, Virginia

Stephen J. Karoly
SIAP Development, Whitney, Bradley and
Brown, Incorporated, Vienna, Virginia

Jon L. Barto
The MITRE Corporation, in support of the SIAP System
Engineering Task Force, Arlington, Virginia

Over a number of years, the U.S. Department of Defense (DoD) has accumulated substantial evidence indicating that significant warfighting capability shortfalls exist in the nation's Integrated Air Defense System (IADS). Post-action reports from military operations, training exercises and joint evaluations point to specific issues needing correction. Engineering analyses have attempted to more clearly define IADS warfighting shortfalls and to recommend engineering solutions to improve performance. To date, most DoD efforts have proven ineffective in correcting systemic, doctrinal and process issues contributing to IADS shortfalls. These shortfalls result in an increased risk of fratricide, reduced capability to operate systems to their full capability and difficulty in addressing emerging threats. Because of these continuing shortfalls, the Joint Requirements Oversight Council established the Single Integrated Air Picture System Engineering Task Force (SIAP SE TF) to lead a joint disciplined system engineering effort to improve IADS warfighting capability. This paper describes SIAP assessments and evaluation issues for engineering improvements in warfighting capability, and it addresses complex issues associated with IADS shortfalls. A joint systems engineering approach that includes appropriate tools, measuring capability, as well as a robust capability assessment, performance evaluation and certification processes, is required to isolate and solve root causes of the IADS shortfalls that plague today's warfighter.

The Department of Defense (DoD) possesses substantial evidence that significant warfighting capability shortfalls currently exist in the capability of U.S. forces to conduct theater air warfare. These shortfalls take the form of functional deficiencies in detecting, tracking, reporting, processing and dispositioning for engagement of aerospace objects in the theater of operations. The systems that provide the capabilities to perform those joint functions are often called the Integrated Air Defense System (IADS). The specific network of tactical datalinks (TDLs) supporting the IADS is often characterized as the Joint Data Network (JDN). Although DoD recognizes the fluid nature of present concept definitions such as joint planning network (JPN), joint data network (JDN) and joint composite tracking network (JCTN), its initial focus will be on establishing recommendations for near-term JDN improvements on the path to a Single Integrated Air Picture (SIAP) capability.

Shortfalls within the JDN generally result in limited DoD capability to reduce the potential of fratricide, to operate weapon systems to their full design capabilities and to improve warfighting capability against emerging threats. These shortfalls have been documented in the: Joint Mission Area Assessment Technology, Architecture and Roadmap Splinter Group report (directed by the Defense Planning Guidance Document [Fiscal Years 2000-2005]); Theater Missile Defense (TMD) Capstone Requirements Document (CRD); Theater Air and Missile Defense (TAMD) Mission Need Statement; TAMD CRD; TAMD

Master Plan; Unified Commanders-in-Chief integrated priority lists; and review of lessons learned from operations, exercises and evaluations such as those conducted by the All-Service Combat Identification Evaluation Team (ASCIET).

ASCIET 2000 observations included a significant number of interoperability problems that prevented establishment of a SIAP and, as expected, adversely affected overall combat identification and mission performance. In most cases, ASCIET 2000 findings were similar, or identical, to those observed during the tests conducted by the Joint Air Defense Operations/Joint Engagement Zone Joint Test Force from 1992 through 1994, and to evaluations conducted by ASCIET from 1995 through 1999. The datalink architecture that supported the joint IADS continued to experience known/repeat integration and interoperability anomalies, which resulted in degraded operational effectiveness. Tactical information and displays at command and communication nodes often were inaccurate, confusing or inoperable as a result of the following problem areas:

■ Track dualing

■ Track identification conflicts/identification swapping

■ Identification Friend or Foe/Selective Identification Feature conflicts

■ Reporting responsibility conflicts

■ Track number changes and swapping of track numbers

■ High net loading on legacy links

It is useful to categorize the causes of individual problems. These categories help focus corrective efforts and assist in explaining causes to a broad audience the following issues:

1) The operating environment's physics

2) Operational availability of individual systems and equipment

3) Design or implementation problems within individual units or in the interface between units caused by: adequate specifications but poor implementation (typically identified as specific computer program "bugs"); ambiguous or overly general specifications that are interpreted differently by system or equipment developers and maintainers; specifications that do not provide the intended result either because they are silent on a particular issue or are improperly stated; or tactics, techniques and procedures (TTP) and training.

Within the third category listed above, some fundamental or "structural" root causes exist that affect warfighting capability. These structural root causes are:

■ Lack of a common time reference across the force;

■ Implementation deficiencies in inertial navigation systems/global positioning systems and integration of navigation functions with the Link 16 network;

■ Poor tracking performance and inaccurate assignment of track quality;

■ Connectivity shortfalls;

■ Failure to achieve a common geodetic coordinate frame;

■ Correlation/de-correlation processing differences; and

■ Automatic identification processing differences.

Understanding that significant warfighting capability shortfalls still exist, DoD has given high priority to improving the capability of U.S. forces to operate both together and with coalition forces. Toward that end, a broad range of organizations and programs have been instituted by DoD components, including the Under Secretary of Defense for Acquisition, Technology and Logistics (USD[AT&L]); Assistant Secretary of Defense for Command, Control, Communications and Intelligence (ASD[C^3I]); DoD Chief Information Officer (DoD CIO); Joint Staff; U.S. Joint Forces Command (USJFCOM); Ballistic Missile Defense Organization; Joint Theater Air and Missile Defense Organization (JTAMDO); and other defense agencies and organizations. However, many of these independent efforts have been ineffective in providing the integrated, interoperable systems that will achieve a SIAP.

As a result, in March 2000, the Joint Requirements Oversight Council (JROC) recommended the designation of a lead system engineering organization to facilitate the translation of the SIAP requirement to a fielded joint capability. In October 2000, under the authority of the Secretary of Defense, the SIAP System Engineering Task Force (SIAP SE TF) was established, chartered by the Vice Chairman, Joint Chiefs of Staff; USD(AT&L); and ASD C^3I/DoD CIO.

The SIAP SE TF is responsible for the system engineering necessary to develop recommendations for systems and system components that collectively support building and maintaining a SIAP capability. To that end, the SIAP SE TF will identify the most effective and efficient means to achieve a SIAP that satisfies the JROC-validated warfighting requirement. The SIAP SE TF is accomplishing this challenging task through a collaborative environment that leverages existing infrastructure and processes. The key focus of SIAP SE TF efforts is implementation of a joint disciplined system engineering process. This process will yield recommendations for fielding a SIAP in order to provide measurable improvements in warfighting capability. The SIAP SE TF is considering the entire spectrum of alternatives, including TTP, to make recommendations on the most cost-effective means to achieve the SIAP.

The SIAP is not the end-state: It is part of a larger construct that must be engineered so that it can easily migrate toward and support a coherent tactical picture (CTP). As such, the SIAP supports joint forces air component commander mission areas involving tactical employment of airpower. An incremental approach is needed to develop and implement improvements to command and control (C^2) of existing systems and the integrated architectures within which these systems operate while the SIAP is being developed.

The SIAP SE TF's charter provides authority for it to:

(1) Develop and maintain a disciplined system engineering process, and to use that process to develop and integrate a SIAP capability. Efforts will be limited to those areas in the following subjects, and only as they relate to the SIAP:

—TAMD Battle Management Command, Control, Communications and Computers (BMC^4I) systems

—JDN and systems that express JDN functionality

—JCTN (pending validation of a JCTN requirement)

—Other joint TADILs, networks, advanced concept technology demonstrations or upgrades as may be assigned by USD(AT&L) or ASD/C^3I and approved by the JROC.

2. Focus initial efforts on identifying, prioritizing and recommending fixes to the existing JDN deficiencies, while ensuring these fixes are on the path to an effective SIAP capability.

3. Submit recommendations for JDN improvements to the JTAMD process, SIAP Acquisition Executive and JROC for approval.

4. Establish the required collaborative engineering environment (including simulations and hardware-in-the-loop [HWIL] capabilities), for problem investigation and for the development, testing and validation of equipment and computer programs that build and maintain the SIAP. Provide feedback from the test and evaluation (T&E) process to USJFCOM so this information can be used to refine TTPs.

Ultimately, the product of the SIAP SE TF recommendations will be combat-ready, operationally certified equipment and computer programs that enable the warfighter to build and maintain a SIAP, as well as inputs to TTP necessary to operate the C^2 components of an integrated system. The JROC will evaluate the SIAP SE's progress during the next two years and, in Fiscal Year 2002, will recommend whether to continue the organization in operation.

Defining the SIAP

The notion of a SIAP is an evolving concept. The earliest JROC-validated definition of a SIAP appeared in the TMD CRD. The recently validated TAMD CRD modifies the earlier definition of SIAP. The TAMD CRD states that, "The SIAP (the air track portion of the CTP) consists of common, continual and unambiguous tracks of airborne objects of interest in the surveillance area. SIAP is derived from real-time and near-real-time data and consists of correlated air object tracks and associated information. The SIAP uses fused real-time and near-real-time data, scalable and filterable, to support situational awareness, battle management and target engagements."

By their nature, such high-level definitions usually lack sufficient detail with which to engineer a SIAP. A SIAP white paper also exists that attempts to provide a more detailed interpretation of what a SIAP is, but it too lacks sufficient fidelity for unambiguously defining the engineering requirements for a SIAP. Consequently, when the SIAP SE TF was chartered, one of its charter requirements was to help refine the definition (and interpretation) of SIAP. Because that work is not yet finished, a fully accepted definition and engineering interpretation of SIAP has yet to be officially provided. However, as the perceived intent of the SIAP concept is projected into the operational environment, a fundamental understanding of the system engineering requirements is beginning to crystallize.

What composes the SIAP?

In its most fundamental form, the SIAP is composed of information on air and space objects of all types: friendly, hostile and unknown. Much of the information is gathered by individual active and passive sensor platforms. SIAP information on friendly platforms often is actively broadcast by those platforms, using a variety of means. The SIAP concept's basic intent is to distribute SIAP-related information from offboard sources to other platforms in-theater to enhance their situational awareness and warfighting effectiveness.

Who uses the SIAP?

In a theater, any tactical platform that may have to interact with, or be aware of, air or space objects, has a need for SIAP information. The quantity and quality of SIAP data needed by any specific platform depend on the platform type, its mission and the mission phase. Many in-theater sensor platforms contribute information to the SIAP from both active and passive sensors. In addition, SIAP information can originate from sensors outside the theater. It also can be self-generated, as in the case of platform position and status reports. All of this information on SIAP objects, when distributed to the right platforms at the right time, can enhance those platforms' mission effectiveness.

How is the SIAP distributed?

The primary means for distributing SIAP information is by tactical datalinks (TDLs). TDLs provide technology-based implementation to satisfy command, control, communication, computers and information (C^4I) exchange requirements. C^4I is the framework for situational awareness, decision-making and execution throughout the battlespace. Efficient execution of information exchange requirements throughout the joint battlespace is key to evolving C^4I toward the ultimate goal of seamless information exchange. The primary component of this infrastructure is the C^4I TDL composed of data elements/messages and physical media. No single TDL supports every C^4I system or is able to operate in all battlefield environments, according to the Joint Tactical Data Link Management Plan, which has cognizance over 18 separate TDLs. These 18 TDLs include the J-Series family of TDLs (that is, Link 16, Link 22 and variable message format C^4I TDLs). Components, services and agencies developing C^4I TDL systems must comply with DoD Directive (DoDD) 4630.5 as amplified by the October 18, 1994 ASD(C^3I) Memorandum, "C^3I Tactical Link Policy." This memorandum "designates the U.S. agreed Link 16 datalink as the DoD primary tactical datalink for all Service and Defense Agency Command and Control (C^2), Intelligence (I),…"

Link 16 uses a single best sensor reporting scheme for objects in a broad-brush moderate quality situational awareness data distribution scheme that is widely distributed. This relatively low-fidelity, wide-area data distribution can be augmented with special high-fidelity data distributions to support specific warfighting functions requiring higher performance and resolution. These high-quality data exchanges typically are confined to a small number of platforms that have a need for such high-quality data. On Link 16, this type of limited distribution is called a subnet. The subnets' distribution limitations are an integral part of the methodology by which Link 16 attempts to efficiently use its limited bandwidth.

Other highly capable new data distribution systems are expected to play an important role in creating a SIAP. These are composite tracking systems such as the Navy's Cooperative Engagement Capability (CEC), and the conceptual extension of CEC into the joint environment under the title of the JCTN. In the context of the overall theater SIAP architecture, the high-quality composite-tracking distributions are similar to the high-speed subnets of Link 16. It is likely that the SIAP architecture of the near future will be some combination of the moderate-quality Link 16 wide-area distributions, higher-quality Link 16 subnet distributions and still higher-quality composite tracking distributions. In the more distant future, it is likely that a continuing migration toward more composite tracking will prevail, provided methods for keeping bandwidth requirements within realizable access limits can be found.

How are the requirements interpreted?

The general shape of the requirement that seems to be emerging is as follows: The SIAP should provide "the right data to the right platform at the right time." In other words, SIAP customers have different data and information needs that they want SIAP to provide for them, depending on their platform type, mission and mission phase. For example, a fighter has different SIAP data quality needs depending on whether it is on its combat air patrol station, has been assigned a mission against an aerospace object or is in a highly dynamic many-on-many air combat engagement.

Engineering interpretation of definitions and terms required

Another key feature of the objective SIAP is that, at the surveillance level, it should provide a *coherent* picture to various platforms viewing the same aerospace objects. That is, if three tactical platforms all are viewing a particular object via the same or different media, such as Link 11, Link 16 and CEC, they should all perceive the object as the same object, and be able to relate it to a common track number and set of associated characteristics. This is the generally accepted interpretation of the terms "single" and "common" as applied to SIAP and its defining references.

On the other hand, one of the often-cited "implied" SIAP requirements is "one and only one track number per target." There are times when this implied requirement is unnecessary, inefficient and perhaps unachievable, and it could work to the detriment of the warfighters the SIAP is supposed to serve. For example, Link 16 currently permits tagging a flight of objects moving together as a "group" track, with a strength field providing information on how many objects that track report represents. If every object required a separate track number in the surveillance portion of Link 16, the efficiency of track grouping would be lost, and fewer objects could be reported in the same amount of capacity.

But Link 16 allows those group tracks to be broken out to individual tracks on more localized subnets. These subnets are intended to be used by "shooters" for whom a single track per target is a necessity for target sorting and engagement coordination. So it is possible, and more efficient in Link 16, to use group tracks, where the fidelity of individual tracks is not needed, and to break down to individual tracks where such detail is necessary.

Both of these approaches meet the needs of certain users. So the question, for such a system (and for the

SIAP SE) is, if the platforms that need the breakout down to the individual target have it (for example, for target sorting or engagement coordination), and others do not, is it accurate to say that the specified SIAP requirement is met or not? The answers to such questions will dictate the engineering solutions that must be fielded to satisfy SIAP requirements.

The desired end-state of the SIAP is improved warfighting effectiveness. In any finite capacity system that may be used to help build the SIAP, especially a multifunctional system such as Link 16, capacity trade issues often come up, and the engineering of the best system (that is, SIAP) to support the customer must consider, and balance, all of the customer's needs (that is, what is best for the SIAP may not always be what is best for the warfighter).

Requirements, by their nature, are not concerned with such mundane existing system and technology limitations. This creates a challenge for the SIAP SE, in that specified SIAP requirements may exceed the ability of existing contributing systems to meet them. In this case, the SIAP SE has some choices. First, he can investigate what portion of the SIAP requirements can reasonably be met with the existing systems, including improvements to, and enhancements of, them. He then can estimate what deltas exist between what can be cost-effectively achieved toward satisfaction of a SIAP requirement with improvements to existing systems, and then develop an approach for satisfying those deltas with new systems.

Another approach might be to define the ultimate system that will meet all of the SIAP requirements. Due to the perceived difficulty, time and lack of resources required to pursue this approach, the SIAP SE has been directed to investigate the application of existing JDN systems to the SIAP requirement. In either case, an engineering interpretation of the SIAP requirements is needed.

JTAMD process

From the SIAP perspective, the JTAMD process is a formalized process designed to define requirements for improving theater air warfare. The JTAMD process impacts potential SIAP customers by developing the SIAP requirements. Again, these SIAP requirements may be met using current systems, or by developing new systems. It is the SIAP SE's responsibility to recommend to the JROC the most cost-effective combination of changes to existing systems and fielding of new systems to meet the JTAMD-developed requirements.

JINTACCS process

The Joint Interoperability of Tactical Command and Control Systems (JINTACCS) process is the current process used by the military services to introduce, analyze and approve changes to many of the SIAP contributing systems, such as TDLs. The formation of the SIAP SE TF by DoD leaders, and current interest in network-centric warfare, appear to be, at their core, a recognition that past processes have been too platform-centric, where the interests of a specific platform have taken precedence over the interests of the whole group. In this context, one of the goals of the creation of the SIAP SE TF is to help elevate the interests of the whole and to provide the engineering rigor that shows—where true—that, with proper balancing of the individual platform and network interests, the whole can be made more effective than the sum of its parts. The SIAP SE will attempt to define specific warfighting benefits that can be measured as part of the justification process for SIAP-recommended changes.

How much SIAP is enough?

A common question is how much SIAP is enough. The answer is different for different platforms. Warfighting needs differ from platform to platform and from one mission and mission phase to another. Therefore, "enough" SIAP means different data for different platforms at different times—that is, a "tailored" picture. Testing for "enough" SIAP thus becomes a test of individual platform time-varying data requirements versus time-varying data delivery. It means that sometimes, for some platforms, group tracks are fine, and it means that, at other times, individual breakouts are required. Success is when the SIAP provides the data in the quantity and quality needed to perform a particular mission and function. "Success with excess" (that is, using more data than is needed to perform a mission or function) unnecessarily consumes bandwidth, which could result in a loss of functionality or performance elsewhere, or loss of growth potential for the system. Either of these scenarios makes "success with excess" a less desirable success than a more efficient one.

Measuring a SIAP

A critical part of SIAP system engineering is identifying the means by which it is understand whether or not warfighting requirements are being met. To close the fire-control loop, the system engineering loop must be closed. The definition of SIAP must lend itself to quantifiable warfighting measures of effectiveness (MOEs), mission-level attributes and system-level measures of performance (MOPs). Once these values are defined, realistic operational tests can be developed to evaluate compliance. As previously noted, SIAP operational requirements are found in the TMD CRD, TAMD CRD and in the draft CRD for combat identification. These operational requirements must be translated, in a traceable way, into lower-level technical requirements that can be used by a disciplined system engineering process, and that can objectively assess progress in achieving the required SIAP capability. However, one of the SIAP SE's jobs is to help evolve the definition of SIAP. This will be natural fallout of the systems engineering efforts undertaken to create a SIAP that most effectively meets warfighter requirements.

Two primary ways of testing exist at the IADS level. The first method uses extensive test networks, in place today, to interconnect the systems that compose an IADS and to challenge this configuration with threat-representative scenarios. This testing shows discontinuities in the interface between individual systems, such as implementation of TDL specifications. These discontinuities, in turn, are resolved by the individual implementing systems. Certifying specification compliance by each individual system is necessary, but not sufficient, to meet IADS requirements.

The second method uses the extensive testing opportunities afforded by the Joint Combat Identification Evaluation Team (JCIET), formerly ASCIET, by service-specific performance evaluations such as the Navy's Battle Group System Integration Test and Amphibious Ready Group System Integration Test, and by exploiting test opportunities during Joint Task Force exercises. These realistic tests and operational exercises provide the most robust testing opportunity available, enabling evaluation of overall IADS performance, including the effects imposed by the operational environment and the effects of training and TTP.

To close the system engineering loop, work must continue across service and system boundaries in order to plan such IADS testing, to assist in test conduct, to carefully analyze the resulting data set and to implement change as necessary. This will require increased participation in JCIET and resource commitments by individual acquisition programs to collect and analyze data. The Joint Integrated Air Defense System Interoperability Working Group (JIADS IWG) is the means by which this work can continue within DoD. The most important JIADS IWG products are the increased communication in the acquisition community, and the training that engineers obtain in developing systems to support joint operations. Assessing capability and performance by way of either of the above methods is supported by three essential elements: measures, tools and processes.

Measures—quantifiable and testable MOEs, attributes and MOPs—are the linchpin to SIAP system engineering efforts. Quantifiable MOPs and MOEs must support various analysis methods, including sensitivity analyses to support technical trade-offs, modeling and simulation (M&S), experimentation, land-based T&E (such as the Joint Distributed Engineering Plant), certification (such as that provided by the Joint Interoperability Test Command) and evaluation in an operational context (such as JCIET) of SIAP-related changes and other warfighting capability improvements. Several efforts have been undertaken to develop a quantifiable set of SIAP-related measures, and such measures provide answers to three fundamental questions:

(1) What do we have today? (evaluative measures);

(2) What is required? (predictive measures);

(3) How do we get what we need? (prescriptive measures).

The quantifying answers to these questions provide an analysis roadmap for system improvement. Ultimately these types of measurements must be evaluated at various levels of performance capability (that is, measurements at the system/platform level, mission/effectiveness, theater and force level). These levels determine a hierarchy of quantifiable characteristics. The flow-down of quantifiable measures from MOEs at the force level to system-level MOPs provides the capability to determine how systemic problems and improvements affect warfighting capability. It is possible to identify hundreds of MOEs. *Table 1* lists several MOEs.

Distance target penetrated blue air space
Number of blue losses to red due to air picture or combat identification
Number of blue losses to blue due to blue being misidentified as red
Area defended per Force Structure
Number of blue defended assets lost; blue casualties

Table 1. Selected measures of effectiveness

MOPs quantify system-level measures, which contribute to increased picture quality. There are potentially thousands of system-level MOPs. Several MOPs are shown in *Table 2*.

Time difference between system internal time at central track stores and the JTIDS terminal
Latency of message due to buffering, prioritization, staleness and time slot allocation
Percent of time units report a valid Global Position Quantity
Translational and rotational errors quantities
Percent of time units correctly report track quality with respect to MILSTD 6016

Table 2. Selected measures of performance

To relate MOPs to MOEs, a handful of quantifiable attributes represent characteristics. While these attributes are quantifiable from system-specific parameters, that is, number of track duals per object and number of track swaps, they relate to MOEs by defining key characteristics of a SIAP. Such attributes have been defined and derived through many efforts including JCIET, Joint Mission Area Assessment and the JTAMD process directly tied to operational requirements. The TAMD CRD lists four attributes that are linked to SIAP key performance parameters. TAMD CRD attributes are provided in *Table 3*.

Completeness of picture—measure of how well objects are detected, tracked and reported
Continuity of picture—measure of the longevity of object tracks
Ambiguity (clarity) of picture—measure of how well one and only one track is assigned to each object
Translational and rotational errors quantities
Timeliness of information—measure of how well the right information gets to the right participating unit in the right amount of time

Table 3. TAMD CRD SIAP attributes

Additional attributes have been identified in the combat identification CRD and TAMD SIAP Technical Architecture Roadmap Study SIAP characteristics (that is, accuracy, commonality). SIAP attributes are mathematically derived from MOPs. Once quantified, SIAP attributes may be flowed to MOEs using appropriate capability assessment tools.

To build a common lexicon and to make progress toward achieving the SIAP, it is critical that the processes and products resulting from the various measures and attributes efforts converge to a standardized, approved set. At a minimum, a standard set of definitions and derivations of SIAP attributes must be established and universally used across services and joint organizations. These attributes provide a common reference to measure a SIAP. In addition, appropriate MOEs and MOPs must be identified and used by testers, analyzers and evaluators such that common criteria may be used to evaluate, predict and prescribe performance.

Capability assessment and performance evaluation tools exist to provide engineering solutions for warfighting shortfalls and to achieve an objective SIAP capability. To level the playing field, and to form a joint reference for using these tools, a common operational context must be established.

The common operational context flows from DoD guidance such as Defense Planning Guidance and the Multi-Service Force Deployment documentation. Within this framework, SIAP evaluations-system enhancements and the resulting impact on warfighter capabilities from the system/unit through the campaign level—may be quantified. The operational framework will contain requirements definition and will support the development and certification of system functional baselines.

Capability assessment and performance evaluation tools include M&S, HWIL tools and operator-in-the-loop (OITL) tools. Many M&S/HWIL/OITL tools exist today, and they are used by the military services and joint organizations to provide an analytical basis for design, development and evaluation of TAMD systems. System-specific and joint integrated tools provide a broad range of analysis capabilities at various measurement levels. By federating models and analytic constructs to support parametric measurements at the system level, variations in system functional performance can be traced to force-level capability improvements. Ultimately, integrated performance is evaluated by final exam in live exercises such as JCIET, ROVING SANDS and OPEVAL.

No one tool can measure the interoperability of what is often called the "family of systems." In fact, measuring "interoperability" is a misnomer. Interoperability in and of itself can only be traced to quantifiable measures, which provide an indication of how well systems are working together. The MOPs, attributes and MOEs described earlier provide these indications.

MOPs, attributes, MOEs and tools are only as good as the processes through which they are used. The complex SIAP environment necessitates a disciplined system engineering process by which capability assessments of system integration can be made and overall performance can be baselined. Processes such as JINTACCS, service and joint certification, and independent operational T&E, all provide methods by which an evaluation can be made of how well systems operate within service mission areas and in the joint context.

To date, these efforts have not been integrated to provide a complete end-to-end process that supports multiple layers of interoperability evaluation. It is only through a continuum of quality that includes the integration of the various configuration control, management and certification processes that DoD can consistently and reliably field warfighting capable systems. Various M&S, HWIL and OITL tools identified along with live exercises must be linked in a reliable and repeatable process to provide the vehicle by which an end-to-end joint certification effort can be maintained. This process must include the following requirements for each tool:

■ Common warfighting scenarios and mission engagement vignettes used across-service and in joint evaluations;

■ Common MOEs, attributes and MOPs by which to quantify performance and capability;

■ A SIAP component of the TAMD integrated architecture, reflecting deployable systems, equipment and computer programs;

■ A joint analysis for "honest broker" data reduction and analysis;

■ Linked results, such that outputs of one tool may be analytically linked to inputs of other tools; and

■ A single joint authority that will enforce the above requirements and can direct that improvements to platform and standards be implemented before systems deploy. This authority also must empower the appropriate organization to enforce configuration control on system computer programs, to ensure that systems are truly certified as interoperable before deployment.

What do the testers get?

Integrated datalink T&E is accomplished through a variety of service-specific and joint organizations. More often than not, assessments are performed that only support organizational and service-specific interests. While scenarios are crafted from joint guidance, and measurements are made from legacy standards, little standardization is actually achieved for joint analysis. The efforts cited above for developing a joint SIAP operational context supported by an integrated architecture and common attributes, MOPs and MOEs, will benchmark the SIAP for the T&E community. This benchmarking provides the capability not only to use analysis from previous M&S, HWIL, OITL and live exercises, but also to potentially improve the conduct of future testing. In addition, benchmarking SIAP testing processes ties developmental testing to operational testing, thus increasing the tester's likelihood of developing robust exercises that both directly support operational requirements and reduce evaluation redundancy.

By reducing redundancy, increasing test robustness and providing the capability to compare and share test results, systemic shortfalls can be identified earlier and then fixed, and live exercises ultimately can be used as IADS performance evaluation tools, rather than as system quality assurance tools. Too many computer program "bugs" are found at joint warfighting assessments and evaluations (that is, at the Joint National Test Facility, Virtual Warfare Center, Joint Interoperability Test Command, ASCIET, ROVING SANDS and so forth).

"Bug-finding" during these events wastes valuable resources, is often too late in the acquisition process to implement "fixes" and constitutes an attempt to "test quality-in" to IADS. Edward Deming warned that this approach is a recipe for disaster. By identifying shortfalls earlier, quality assurance can be moved back into the factory and into the program-specific laboratory environment. Joint exercises, both live and virtual, must provide decision-makers with cost-effective analysis tools to support platform warfighting. ❑

CDR Joseph N. Giaquinto, USN, reported in August 2000 to the Single Integrated Air Picture (SIAP) Systems Engineering Task Force, Arlington, Virginia, as the analysis branch head. CDR Giaquinto's early assignments have included duty at: numerous service schools; Navy Recruiting District, New Jersey; 2nd Air and Naval Gunfire Liaison Company, Camp Lejeune, North Carolina; and USS Lawrence *(DDG-4), homeported in Norfolk, Virginia. Other assignments have included: an engineering duty officer (EDO) assignment at the Naval Surface Warfare Center, Dahlgren, Virginia; Strategic Systems Programs (SSP) Detachment, Magna, Utah, in various capacities; the Office of the Under Secretary of Defense for Acquisition (OUSD[A]), Strategic and Space Systems, as the principal OUSD(A) action officer for Navy Theater Ballistic Missile Defense (TBMD); and Engineering Duty Officer School, Port Hueneme, California. CDR Giaquinto received his commission from the U.S. Naval Academy, Annapolis, Maryland, in 1980, and graduated with a bachelor of science degree in aerospace engineering. He graduated from the Naval Postgraduate School, Monterey, California, in 1989, with a master of science degree in electrical engineering. In 1991, he completed the Program Manager's Course at the Defense Systems Management College, Fort Belvoir, Virginia.*

Stephen J. Karoly is a senior manager at Whitney, Bradley and Brown, Incorporated, a consulting and technical services firm located in Vienna, Virginia, where he has worked since 1997. Currently, Karoly is providing program management and system engineering support to the Single Integrated Air Picture (SIAP) System Engineering Task Force. He served seven years in the U.S. Navy as a surface warfare officer and continues to serve in the U.S. Naval Reserve, currently in the rank of commander. He graduated from the U.S. Merchant Marine Academy in 1985 with a bachelor of science degree in marine engineering/nautical science.

Jon L. Barto is a lead communications engineer in D440 (Architecture and Interoperability), the MITRE Corporation. Barto is currently supporting Air Force and Joint Single Integrated Air Picture (SIAP) development efforts. He joined MITRE in 1989, after a 25-year career as a U.S. Navy fighter pilot and as an aeronautical engineering duty officer. Barto's primary activities at MITRE have all involved Link 16, having worked for the Link 16 Joint Program Office (JPO) and Air Force Tactical Data Link Systems Integration Office (SIO) for more than 16 years, including his last Navy tour as Joint Tactical Information Distribution System (JTIDS) project officer at JPO. He has primarily been working with the joint community (military services, Ballistic Missile Defense Organization and Joint Theater Air and Missile Defense Office [JTAMDO]) on various applications of Link 16 to joint tactical missions, including TBMD, air defense and air-to-ground operations. In 1965, Barto earned his bachelor of science degree in naval engineering from the U.S. Naval Academy, and his master of science degree in aerospace physics in 1973 from the U.S. Naval Postgraduate School.